OUR BOOKSHELF.

A Manual of Oils, Resins, and Paints, for Students and Practical Men. By Dr. H. Ingle. Vol. I., Analysis and Valuation, by the author and J. A. L. Sutcliffe. Pp. 129. (London: C. Griffin and Co., Ltd., 1915.) 3*s.* 6*d.* net.

THIS small volume is intended for students, analysts, and works chemists who are familiar with general chemistry but have had little or no practical experience in analysing oils, or preparations which contain oils. It includes much of what one would put in a good notebook intended for personal use in the laboratory. A short introduction serves to refresh the reader's memory upon points in organic chemistry specially relevant to oils and fats, after which the authors give short accounts of the most approved chemical and physical methods used in examining these bodies. Theoretical explanations are included as well as practical details. For example, the chemical reactions concerned in the absorption of iodine by oils are described more fully than usual—though it is true that we have to look in more than one place for them. A chapter on technological analysis deals not only with oils, fats, and waxes as such, but with articles such as paints, pigments, and varnishes which may contain oil as an ingredient, and with allied substances, such as turpentine and gum-resins.

The correct interpretation of the results obtained would often require much more knowledge than could be obtained from the descriptions given. Information as to the origin and methods of preparation of the various oils is not within the scope of the work. It is understood, however, that further volumes are to follow, dealing with these matters. The book is a useful introduction to laboratory work in the subject.

Potting, for Artists, Craftsmen, and Teachers. By G. J. Cox. Pp. ix+200. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1914.) Price 5*s.* 6*d.* net.

THE book will prove a distinct help to an artist craftsman who wishes to "do something" with clay. The author is right in saying: "Too much stress cannot be laid upon the importance of close study of the best work, both ancient and modern, for it is a truism that however handily a craftsman may work, his output will be worthless if he has not, with his increasing powers of technique, developed a sound judgment and refined taste." The description of the various simple processes of pottery work is very exact, and the illustrations are admirable.

The book, indeed, is a simple, though thorough and concise, first tutor to an artist craftsman, and should, to use the author's words, "set one or two sincere students to the making of some of the many beautiful objects of utility and art with which the craft abounds."

The list of pottery terms is useful, though there are a few which are not employed in this country in the sense given by the author, for example, *clammings* in England means the doors of the kiln, and not simply the sand or siftings applied to the cracks in them; *pug* in this country is used to mean the mechanical wedging of clay; *galena* is classed by the author as highly poisonous, and lead as poisonous, whereas galena is practically safe to use, but there may be considerable danger in using white lead carelessly.

BERNARD MOORE.

LETTERS TO THE EDITOR.

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The Principle of Similitude.

WHEN Lord Rayleigh directs attention to the neglect among physicists of the principle of similitude (NATURE, March 18), he has perhaps forgotten the excellent paragraph in which Tait deals with the question in his "Properties of Matter." Curiously enough, one of Lord Rayleigh's first illustrations is also Tait's, namely, the fact that the velocity of waves on deep water is as the square root of their lengths, to which Tait adds the corresponding fact that the velocity of ripples is inversely in the same proportion.

The principle is of great use in biology, as Herbert Spencer was the first to show. By its help we understand how there is a limit set to the possible growth in magnitude of terrestrial animals; how, on the other hand, the whale gains in activity and speed the bigger it grows; why the ostrich is unable to fly; why the bee's wing vibrates so much quicker than a bird's; and why the flea can jump well-nigh as high as a man. And not less does the principle deserve to be borne in mind when we consider what must be the conditions of life in the most minute organisms: especially if there be any so small as that Micrococcus of the rabbit, the diameter of which is given in the books as only 0·00015 mm., or not far from the limits of microscopic vision.

D'ARCY W. THOMPSON.

IT is rather curious that Prof. D'Arcy Thompson should refer to Tait's "Properties of Matter," for I fancy I might claim some part of the credit for the paragraph in question. In a review of the first edition (NATURE, vol. xxxii., p. 314, 1885) I wrote:—"There is one matter suitable to an elementary work which I should be glad to see included in a future edition, viz., the principle of dynamical similarity, or the influence of scale upon dynamical and physical phenomena. It often happens that simple reasoning founded upon this principle tells us nearly all that is to be learned from even a successful mathematical investigation, and in the numerous cases where such an investigation is beyond our powers, the principle gives us information of the utmost importance."

And, after an example or two: "I feel sure that in Prof. Tait's hands this very important and fundamental principle might be made intelligible to the great mass of physical students." Though I believe I was in correspondence with him at the time, I do not remember to have seen Tait's second (or later) edition,

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and I can only wonder that it has not had a more marked effect in popularising the general principle.

Prof. Thompson's illustrations from biology (attributed in part to Spencer) are, of course, of first-rate importance.

Rayleigh.

The Age of the Earth.

Some fifty years ago Kelvin announced that the temperature of the earth could not have been anything like its present value for more than some 20–30 million years. This estimate was based upon three independent considerations, namely, the temperature gradient inside the earth's crust, the amount of tidal friction, and the total amount of energy radiated by the sun.

The first of these arguments has been invalidated completely by the discovery of the radio-active elements. The other two arguments are scarcely affected by this event.

The geologists always found some difficulty in compressing the history of the earth, more especially of the sedimentary strata, into the period allowed them by Kelvin. Prof. Harker's presidential address before the Yorkshire Geological Society, reprinted in your issue of March 25, seems to show that there is a general impression abroad that Kelvin's estimates have been superseded, and that the discoveries in radio-activity allow one to assume a period of the order of thousands of millions of years since the earth has reached a constant state as regards climate. I should like to be allowed to state as succinctly as possible what difficulties this view entails.

The mean temperature of the earth is about 280° absolute. It therefore radiates about $1{\cdot}7 \times 10^{24}$ ergs per second into space.

Assuming the latest value $1{\cdot}92 \frac{\text{cal}}{\text{cm.}^2\,\text{min.}}$ for the solar constant, the earth receives $1{\cdot}72 \times 10^{24}$ ergs per second from the sun. Therefore the radiation from the sun just compensates the amount lost by the earth; in other words, the temperature of the earth is determined by the temperature of the sun. The possibility that the earth's temperature might have been maintained by radio-active processes before the sun was incandescent, and that the radio-active substances have died off since then need scarcely be discussed seriously. For quite apart from the well-known sterilising effects of the rays, any radio-active substances with a sufficiently long life to keep up the temperature of the earth for any considerable length of time would not disappear quickly. Uranium, for instance, only diminishes at the rate of about 1 5 per cent. in 100 million years.

One may conclude, therefore, that the time during which the earth can have existed in its present state cannot be greater than the time since which the effective temperature of the sun has been about 6000°, its present value. This time cannot exceed about thirty million years. For the sun loses energy at the rate of about $3{\cdot}8 \times 10^{33} \frac{\text{ergs}}{\text{sec.}}$, and the total energy to be gained by a mass of $1{\cdot}97 \times 10^{33}$ gm., contracting to a radius $6{\cdot}96 \times 10^{10}$ cm., is $2{\cdot}2 \times 10^{48}$ ergs, assuming approximate homogeneity. (Taking the increase in density towards the centre into account does not alter these figures much.)' Now even if one assumes that the whole of this energy was radiated at a rate of about $3{\cdot}8 \times 10^{33} \frac{\text{erg}}{\text{sec.}}$, *i.e.*, at the present rate, it will only last 18·3 million years. But any other supposition, namely, that the sun at one time emitted more or less energy per second, leads to a shorter period for the earth in its present state.

To explain a greater age it was necessary to find other sources of energy, and since neither the heat of chemical combination nor any possible increase in the specific heat was anything like large enough, the heat of radio-active transformations was invoked. This was perhaps excusable in the early days before very much was known about the laws governing these processes, but it seems quite inadmissible to-day.

It has been suggested that at the enormous pressure and temperature inside the sun radio-active processes might be modified, and even that ordinary elements might break up. A consideration of the quantitative relations involved shows that this is most unlikely. Though one can scarcely apply ordinary thermodynamics to radio-active processes one can certainly apply the general rule, which may also be developed from the quantum theory if desired, namely, that a reaction the energy of which is A ergs per molecule is affected chiefly by the collisions of atoms of energy of the order A. Now A is of the order 10^{-5} ergs in radio-active processes, and one can therefore only expect the temperature to affect those if an appreciable number of atoms have an amount of energy of this order. The average energy of an atom would be 10^{-5} ergs at about $5{\cdot}10^{10}$ degrees. Therefore even at 500 million degrees only one atom amongst 10^{40} would be moving fast enough to influence a reaction which liberates 10^{-5} ergs. Obviously 500 million degrees is quite beyond the bounds of possibility in any part of the sun. One must conclude, therefore, that any process which liberates anything like the requisite energy is unaffected by solar conditions, and takes place at the same rate on the sun as on the earth. Thus one must fall back upon the ordinary radio-active materials, and as Sir Ernest Rutherford has pointed out, one would only gain a paltry five million years even if the whole sun were composed of uranium. The only way out would seem to be to suppose that the sun was created some 10^9 or 10^{10} years ago out of special radio-active material which produces an enormous amount of energy, and that it has been breaking up ever since. This material does not exist on the earth though, so the earth would have to be the object of a special creation. Such an assumption, of course, can neither be controverted nor even discussed. But unless some such hypothesis is introduced, *i.e.*, unless the presumably radio-active solar material which liberates a quantity of energy sufficient to keep up the sun's heat for the desired 10^9 or 10^{10} years, is supposed to have been created by some inconceivable force at the epoch at which the sun is supposed to have begun to radiate, this material would have disintegrated long ago. It might be objected that the same holds good of uranium, that the fact that uranium exists in measurable quantities proves that it has not existed for a time great in comparison to $5{\cdot}10^9$ years.

This is doubtless true, but there is no real difficulty about assuming uranium or other radio-active substances to have been produced if one supposes the solar system to have been formed by the collision of two stars.

At the moment of collision the velocity of two stars half the mass of the sun would be $\frac{1{\cdot}15 \times 10^{13}}{\sqrt{r}} \frac{\text{cm.}}{\text{sec.}}$, r being the distance between the centres of gravity. Suppose they both contained some lead, this would reach a temperature of the order $\frac{1{\cdot}1 \times 10^{20}}{r}$, *i.e.*, of the order $2{\cdot}10^9$ degrees at the moment of collision. As has been shown above, an appreciable quantity of radio-active

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